LOGICAL SURVEY OF NEW JERSEY.

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ANNUAL REPORT

OF THE

STATE GEOLOGIST,

FOR THE YEAR

1887.

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THE JOHN L. MURPHY PUBLISHING CO., PRINTERS.
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NEW BRUNSWICK, December 20th, 1887.

To His Excellency Robert S. Green, Governor of the State of New Jersey, and ex-officio President of the Board of Managers of the State Geological Survey:

SIR—I have the honor herewith to submit my annual report, as State Geologist, for the year 1887.

With high respect,

Your obedient servant,

GEO. H. COOK,
State Geologist.

REPORT.

The main work of the Geological Survey during the year 1887 has been given to the completion of the Topographical Survey and maps of the State. The office in New Brunswick has been open and the large correspondence connected with various departments of the work has been kept up. The distribution of the publications of the Survey, which has gradually grown to be an important part of its duties, has received full attention. There has also been some field work done in the exploration and study of the Archæan rocks in Sussex county. This has been in continuation of plans given in former reports. Some examinations have also been made of the glacial and terrace deposits in the valley of the Delaware above the Water Gap. There has also been a careful and detailed survey made of the zinc mines at Franklin Furnace, for the purpose of making a model of this extraordinary vein of ore. The extensive workings of the mines have so exposed the rocky strata that it has become the best-known illustration of some of the structural features of the Highland range of mountains. Attention has also been given to the important questions of water-supply and of drainage.

The near completion of the work renders it unadvisable to go into detail as fully as has been the case in former annual reports. The present is only a business statement of the affairs of the Survey, and it is soon to be followed by the first part of the final report. This will be ready for the printer the latter part of the winter. It will be upon the Physical Geography of New Jersey, and will embody in the text the results of the Geodetic, Topographic and Magnetic Surveys, and be a proper accompaniment to the elaborate maps which are now done and nearly all ready for publication.

It is gratifying to be able to state that the work and publications of the Survey are satisfactorily meeting the wants of our citizens. Constant reference is being made to the office for the reliable information which is contained in the surveys and records, and important

enterprises are being undertaken from the information which has been thus provided by the State.

The matters noticed in the report are arranged under the following heads:

I. GEODETIC SURVEY.

II. TOPOGRAPHIC SURVEY.

III. GEOLOGIC SURVEYS.

IV. WATER-SUPPLY.

V. DRAINAGE.

VI. MISCELLANEOUS SUBJECTS NOTICED.

VII. PUBLICATIONS.

VIII. EXPENSES.

IX. ASSISTANTS.

X. STATISTICS OF IRON AND ZINC ORES.

I.
GEODETIC SURVEY.

PROF. BOWSER'S REPORT.

NEW BRUNSWICK, N. J., December 19th, 1887.

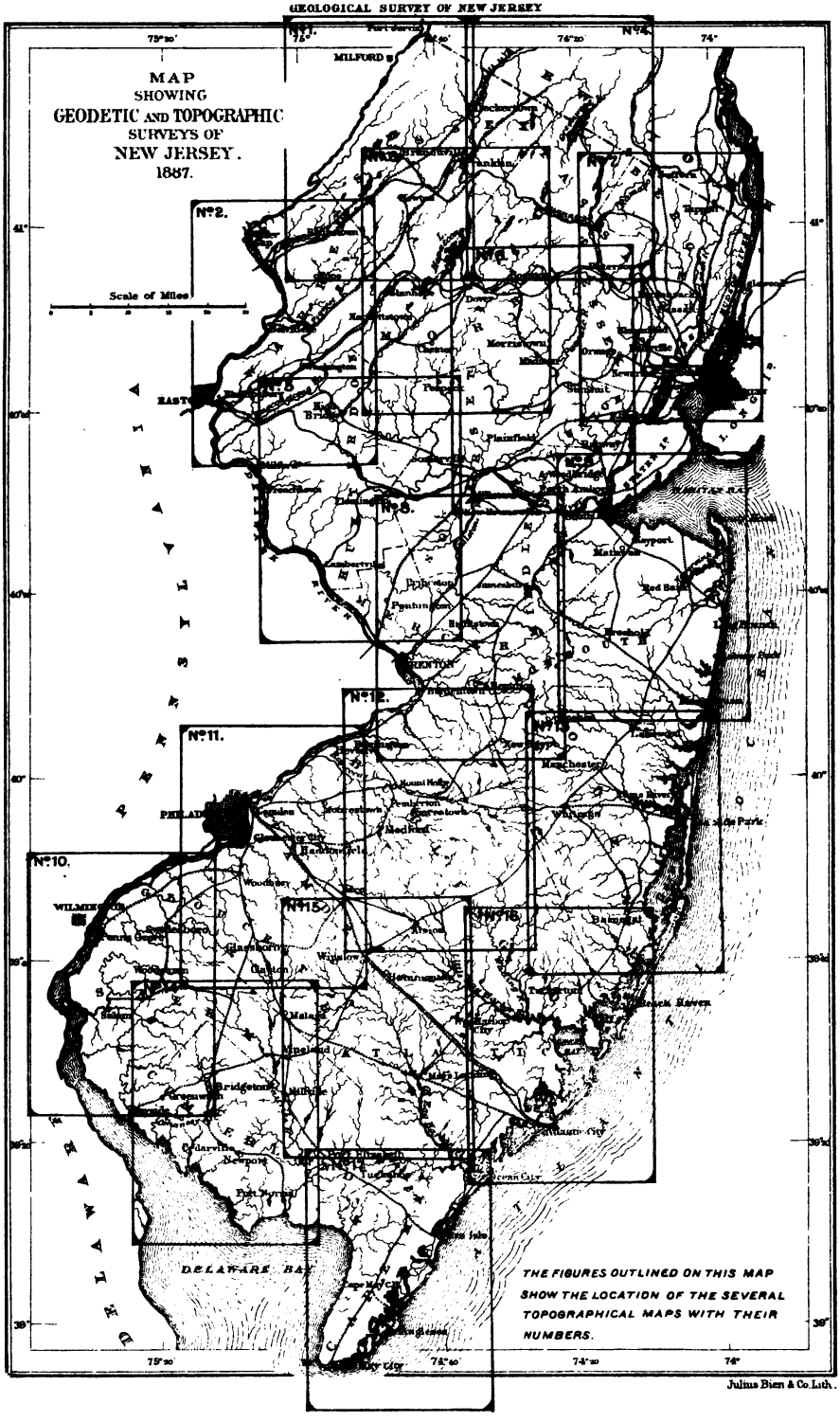
During the present season, the U. S. Geodetic Survey of N. J. has been continued southerly and southwesterly from the line Hammonton-Blangie, which was reached in 1886. As the appropriation for the Survey, for the present year, like the one of last year, was only about half as large as usual, but a small amount of work has been done.

During the season the primary stations Richland and Newfield were occupied and the observations completed. Observations were also made from these primaries upon the following tertiary signals:

Vineland church spire.
Weymouth smoke-stack.
Forest Grove church spire.
Egg Harbor City church spire.
Buckhorn Mills smoke-stack.
Elwood church spire.
New Germany church spire.
Doughty's Tavern flag-staff.
Roman Catholic Seminary at Vineland.
Clayton church spire.
Glassboro church spire.
Williamstown church spire.
Pleasantville church spire.
Buena Vista.
Deerfield.
Daretown.

The reconnoissance was continued westerly, and the primary station Colson's established.

The reconnoissance for selecting the stations is very difficult, owing to the exceeding flatness of the country, and the large areas of thick, tall timber, much of it being 80 to 100 feet high. The next stations to be occupied are Williamstown, Bridgeton and Colson's. As the lines connecting these stations are quite long, and run over a very level country, and through much timber, some of which is 90 and 100 feet high, it will be necessary to build observing towers at least 64 feet in height and to open vistas through the tops of the intervening woods. The building of these towers, and the running of the lines to locate the vistas, and opening them, will be very expensive; and unless, therefore, there be a larger appropriation the coming year than there was in either of the last two years, the amount of observing done during the coming season must necessarily be greatly diminished.


MAP
SHOWING
GEODETIC AND TOPOGRAPHIC
SURVEYS OF
NEW JERSEY.
1887.
Scale of Miles
No.1.
No.2.
No.3.
No.4.
No.5.
No.6.
No.7.
No.8.
No.9.
No.10.
No.11.
No.12.
No.13.
No.14.
No.15.
No.16.
EAST
TRENTON
PHILADA
WILMINGTON
DELAWARE BAY
THE FIGURES OUTLINED ON THIS MAP SHOW THE LOCATION OF THE SEVERAL TOPOGRAPHICAL MAPS WITH THEIR NUMBERS.
Julius Bien & Co. Lith.

II.
TOPOGRAPHIC SURVEY.

MR. VERMEULE'S REPORT.

The field work of the Topographical Survey is completed, the operations of the year having been directed to the revision of the area in the northeastern part of the State, which was covered by the map of 1882, which was in part compiled from other surveys, and subsequently utilized in making up the preliminary editions of Atlas Sheets Nos. 6 and 7. This was the work reported as remaining to be done at the close of 1886. It has now all been covered by original surveys.

The first three months of this year were devoted to mapping the field work of 1886, covering an area of 1,800 square miles. The parties took the field April 5th, and Messrs. F. W. Bennett, P. H. Bevier, W. H. Luster, Jr., P. D. Staats and Asher Atkinson, Assistant Topographers, with their aids, were mainly employed in contouring and surveying topography up to near the close of July. Messrs. Luster, Staats and Atkinson were then detailed to add the forestry to the maps of Northern New Jersey, where this feature was at first omitted. Being included in later sheets, it was found so desirable for indicating the position and relative amounts of improved and unimproved lands, as well as the areas remaining devoted to forestry in the State, that it was thought best to add it to all sheets. This work was finished about the middle of October.

Messrs. F. W. Bennett and P. H. Bevier resumed the running of levels for bench-marks August 1st, and this work was continued by Mr. Bevier until September 30th and by Mr. Bennett until October 13th. The following lines were run: Manahawken to Barnegat Light and return, 28 miles; Somerville to Flemington, 15 miles; Easton, Pa., via Belvidere, to Washington, 28 miles; Freehold to Kingston, 22 miles; Perth Amboy, via Newark and Jersey City, to Paterson, 46 miles; Newark, via Paterson, to Waterloo and Newton,

61 miles; Newton to Carpenter's Point, to Deckertown, to Andover, 62 miles; Paterson to Suffern, to Tappan, to Fairview, 49 miles. The total distance run during the year is 311 miles. It is intended to publish a complete list of bench-marks in a forthcoming volume of the final report.

Upon completing the above work Messrs. F. W. Bennett and Asher Atkinson were detailed to execute a Magnetic Survey of the State. Some curious facts had been noted as to the occurrence of local attraction during the prosecution of the Topographic Survey, and it is believed that this survey will not only furnish results of general scientific interest, but will prove an aid to land surveyors, contributing to the accuracy of local surveys and aiding in retracing old lines by pointing out the rapid but uniform change of declination which takes place in some localities in the State, amounting in one observed case to one and one-half degrees in four miles. This survey has been completed and its results will be published in the final report.

MAPPING AND ENGRAVING.

Mr. Frank Van Brakle has been engaged throughout the year in mapping, being aided at various times by other members of the corps. The work has followed closely the surveying and the original topographical sheets, on a scale of three inches to a mile, were all completed November 7th, and placed in the engraver's hands. These sheets are now filed in the safe in the office of the Survey and are available for publication on a larger scale than that of the general atlas, should the geological investigations or economic needs of certain sections require it.

The preparation of copy for the small map of the State, on a scale of five miles to an inch, has also necessitated some office work. The engraving has been advanced as rapidly as the copy could be prepared, and at this date all engravings on the inch scale, excepting a small portion of the revision work on Atlas Sheets Nos. 6 and 7, has been completed. The engraving of the small map of the State, on a scale of five miles to an inch, is also completed, and the printed map accompanies this report.

Publication has promptly followed the engraving. Atlas Sheets Nos. 8, 11 and 12 were published January 25th; No. 5, April 15th;

Nos. 10, 14 and 15, October 4th, and the State map sheet is published herewith. This completes the Topographical Atlas.

The small amount of engraving yet to be done may be completed in March, and revised editions of Atlas Sheets Nos. 6 and 7 will then be published. This and the collation of matter scattered through the voluminous field-notes of the Survey, and digesting and arranging it in form for convenient use, constitute the only work remaining to be done before the Topographical Survey is closed.

PLAN OF PUBLICATION.

The receipt of many inquiries as to the published maps makes it necessary to reprint yearly the following description of the system of publication of the results of the survey:

All the manuscript maps of the survey are on a scale of three inches to a mile, or 1 in 21,120. These sheets average 5x10 feet in size, and are twenty in number.

The engraving is executed on a scale of one inch to a mile, or 1 in 63,360, and each of the above sheets requires four stones about 17 by 18 inches in size, two being for roads, streams and lettering, and two for the contour lines, making 80 stones in all. Several of these stones are grouped on one transfer stone to form an atlas sheet. These are all of the same size, and as large as they can be conveniently printed on a single sheet of paper. After a number of trials to ascertain what would best fit the irregular shape of the State, and the geological belts which cross it obliquely, having regard also to the location of important centers of population and business, the plan shown on the accompanying small map of the State was adopted.

The entire State requires 17 sheets to cover it. Each sheet is 24x34 inches in size. At first view it will be thought that they overlap each other and require an extra amount of engraving. The overlapping is not more than enough to give room for titles to the maps, and the engraving is not increased, as the printing is not done from the engraved stones directly, but from transfers which can be joined together in any way that may be required.

The numbering of the maps is generally from the north towards the south, and they are arranged so that those covering the same geological formation can be easily grouped together, thus:

Nos. 1, 2, 3 and 4 cover all the Archæan and Paleozoic rocks.
Nos. 2, 3 and 4 cover all the Archæan rocks and all the iron ore district of the State.
Nos. 5, 6, 7 and 8 cover the red sandstone formations.
Nos. 8 and 9, with 10, 11 and 12, cover the clay and marl districts of the State.
Nos. 8, 9, 10, 11, 12, 13, 14, 15, 16 and 17 cover the Tertiary formations.
Nos. 9, 13, 16 and 17 cover the entire Atlantic shore.

The sheets can be taken separately or the whole together. The maps are all drawn on the same system of projection, so that any two adjoining ones can be cut, fitted accurately to each other, and made into a single map, or they can be folded across and put in an atlas of 17x24 inches. These, with a map of the whole State, on a scale of five miles to an inch, on the same sized sheet with the others, make up the Topographical Atlas of New Jersey.

THE AIMS AND RESULTS OF THE TOPOGRAPHICAL SURVEY.

This survey was begun in 1877, to meet the imperative wants of the Geological Survey and the demand for good maps for economic uses in a rapidly-advancing community. It was designed to produce primarily a topographical map, as accurate as the scale of one inch to a mile would admit of; with the addition of as much information of a purely economic nature as could be introduced without interfering with this object. It has been conceded to be the pioneer Topographical Survey of America. Some of its results have now been several years before the public, and as it covers a district which is densely populated, and perhaps more carefully worked over by civil engineers, in designing and executing public works, by geologists and other close observers, many of whom have borne testimony as to its practical value, we have the pleasant assurance that the survey has fully accomplished its object, and in some directions even more than it was originally expected to do. As yet there is no reason to doubt that the work has been designed and executed in a manner which best subserves the interests of the State.

It is only to be expected that a community so highly developed and wealthy will, before many years have passed, demand a cadastral

and economic survey such as European states of like density of population are prosecuting. With the present Topographical Survey in hand to fill our immediate necessities we are prepared to proceed with such a work with the deliberation and care which its character will demand. The greater scope of usefulness of a Topographical Survey enables it to give larger returns for the comparatively small amount expended in it, and forbids that it shall be indefinitely delayed and withheld from its fields of usefulness by being in any way connected with or dependent upon the completion of these necessarily tedious and expensive cadastral or economic surveys. This lesson has been learned everywhere in Europe, where state surveys have reached a high development.

COST OF THE TOPOGRAPHICAL SURVEY.

The whole amount expended for salaries and expenses of the topographical corps in field and office during the prosecution of the work has been $59,892.95. Of this amount, $5,148.37 was devoted to work not chargeable to the Topographical Survey proper, leaving $54,744.58 as the total cost of field work and the preparation of manuscript maps on a scale of 3 inches to a mile. This amounts to $6.93 per square mile, or one and one-twelfth cents per acre. It includes a triangulation covering 2,000 square miles, and a large amount of proof-reading, work on reports and other office work incidental to all surveys. By promptly availing herself of the offers of co-operation in the work and its results extended by the national surveys to all states undertaking and prosecuting surveys of their domain, New Jersey has secured this survey at a cost of but half the above sum, the remainder being borne by the national organizations. The topography found already executed reduced the cost of topographical work about fifty cents per square mile, while our experience shows that had we also been compelled to furnish our own triangulation the cost of executing it in a manner just suitable for the needs of the Topographic Survey would have swelled the total expense to nearly, but certainly not more than $10 per square mile.

While we claim for the Survey that it is as accurate as the publication scale demands, and in many places much more accurate than this scale warrants, being intended to serve as the basis for larger scale

maps of important sections when they are needed, we of course consider it but fair that its small cost should be kept in view in judging of its merits.

CONTROL OF THE TOPOGRAPHY.

A good estimate of the accuracy of the results of the survey can only be formed from a personal inspection of the maps in the field. As already noted, many competent judges have made this inspection and have expressed themselves satisfied. But for the benefit of those who cannot do so, but still wish to form an opinion as to the accuracy of the work, we submit a short statement of the measured control of the survey. Keeping in mind the fact that topography is made up of irregular curved surfaces and lines, which can only be determined mathematically by the location of an infinite number of points, it will be seen at once that mere measurement alone will never suffice to produce a topographical map. All good topography is executed by the aid of sketching, and therefore the number, distribution and accuracy of the measurements which control the sketch, together with the truthfulness of the sketching, which varies with the largely innate qualifications of the topographer for his work, serve as a measure of the quality of the result.

Primarily, the control of this work rests on a triangulation by the United States Coast and Geodetic Survey, filled out and extended by the topographers so as to include a total of 458 stations, determined with what we may consider absolute accuracy. These stations are very close along the sea-coast and large rivers, but in the interior they average one to each twenty-five square miles and are about five miles apart. The next step in securing measured control is the running of traverse lines over the whole area at an average of 2.53 miles of traverse to each square mile of territory, which is equivalent to a rectangular network with squares having sides of four-fifths of a mile. In important districts the lines are closer; in flat, level and unimportant sections they are farther apart. The distribution of the highways being suitable for the purpose, they have been mainly followed in traversing, for convenience, the work being done with facility and suitable accuracy with a barrow odometer. A transit and stadia were sometimes substituted when the other method was inapplicable. From this network of traverse lines, which were closely connected with and adjusted to the triangulation, all important points of topography were

located by traversing with a prismatic compass and pacing, these paced lines being checked out on a main traverse line opposite to the one from which the start was made. All streams of importance were followed in this way, and all summits and ridge-lines were thus visited, studied and located. It has been found that an experienced topographer can by such means secure good location, and results as accurate generally as the scale can exhibit. Topographers have averaged over four miles of walking to each square mile of sketching, thus studying and representing all topography at short range. The bays, creeks and marshes of the coast, as well as important rivers, were surveyed with transit and stadia. Heights have been determined almost entirely by the spirit-level. A network of primary levels formed the basis for this work, the levels for topography being run rapidly with a light engineer's level. Elevations may be relied on to the nearest foot. This accuracy was deemed necessary because of the extensive use made of the work in the solution of important engineering problems of water-supply, drainage, etc., and the many demands made on the survey for accurate data for such purposes. To secure it may have added somewhat to the cost of the survey, but no one familiar with the growing importance of these questions to the greater portion of the people of the State will doubt that the increased efficiency thus secured will well repay this.

The following table exhibits fully the amount of instrumental work which has been done to secure good control for the topography.

The most natural classification of the topography is one conforming to the geological structure. This classification has been followed in the table. The Archæan and Paleozoic districts are hilly or mountainous in character, consisting of ridges and irregular plateaus, rising to 1,800 feet above the sea and quite frequently 1,000 feet above the neighboring valleys. The area in timber varies from 40 to over 90 per cent., and this increased the cost of surveying. Triassic topography consists of a rolling plain, occasionally broken by protruding ridges of trap-rock. Forests cover from 25 to 50 per cent. of the area. Cretaceous topography is made up of irregular low hills, rising to about 350 feet above the sea at the highest part, or of gently undulating plains, traversed usually by crooked ravines with steep banks and flat bottoms. The first portion has about 40 per cent. in timber, the latter not over 20 per cent., but the whole area is

covered with many scattering tree-clumps and hedge-rows, which interfere considerably in topographical work. The timber in this area is also very tall. The Tertiary formation is represented by extensive and extremely level plains of sand, covered by a pine forest. The streams meander through flat valleys and are usually bordered by impenetrable swamps of white cedar, often miles in width. Elevations seldom rise above 200 feet. The sea and Delaware bay shores are fringed by open tide-marshes, traversed by an intricate network of creeks and broken by many bays.

The leveling and odometer traversing were confined to 7,415 square miles of upland. The methods of surveying tide-marsh were different. The transit work was mainly on the latter area. The areas in the first column are based on the results of a new measurement of the area of the State which is not quite completed. The total area given excludes the large water areas of Delaware and Raritan bays.

SUMMARY OF WORK OF THE TOPOGRAPHICAL SURVEY.

District.	Area.	Leveling.			Traversing with odometer.		
		Number of Miles.	Miles per Square Mile.	Stations per Square Mile.	Number of Miles.	Miles per Square Mile.	Number of Stations.
Archæan and Paleozoic	1,524	3,435	2.25	14.2	3,429	2.25	.....
Triassic	1,551	4,192	2.70	15.1	4,920	2.50 to 6.40	.....
Cretaceous and Tertiary	4,340	6,948	1.60	7.2	10,419	2.40	.....
Averages and Totals	7,415	14,575	1.97	10.2	18,768	2.53	211,679
Primary Levels	.....	1,114	Transit Traverse.		956	.....	3,576
Grand Total	7,894	15,689	.....	.....	19,724	.....	215,255

The points determined by triangulation by the topographical parties number 156, making with those furnished by the United States Coast and Geodetic Survey a total of 458 points utilized in the maps.

The above is a sufficient exhibit of the control of the sketching. Taken with what has been said of the manner of executing the sketching it should serve as a measure of the reliance to be placed on the results.

The following time record of the survey will serve to show the proportion of labor devoted to each portion of the work. The time given is in days' work of one man. The topographer in charge carried on triangulation and other field and office work in person, supervising the work of the party at the same time, as much as possible. When the whole of his time was required for administrative duties this time has been charged to supervision, otherwise to the class of work in which he was mainly engaged.

	Days' Work.
Leveling and sketching simultaneously	8,082
Sketching, without leveling	760
Primary leveling, without sketching	708
Traversing, with odometer	2,145
Transit traversing	713
Triangulation	467
Office work, including platting and also much miscellaneous work incidental to all surveys	4,159
Supervision	892
Total	17,926

No deduction is made for Sundays or for stormy days in the above record. It includes all of the time devoted to work which appears in the results of the Topographical Survey proper, excluding a considerable amount of miscellaneous office work having no bearing on these results.

C. C. V.

III.
GEOLOGIC SURVEYS.

The survey of the region occupied by the Archæan rocks is in progress. In former reports Prof. Smock has called attention to the occurrence of areas of Massive rocks in different parts of this region, and Dr. Britton has proposed to classify the rocks of the region in three divisions, viz.:

1. *Massive rocks,* the lowest.
2. *Iron-ore bearing rocks,* next above.
3. *Schistose rocks,* the highest.

Almost the whole Archæan system of the Highlands in New Jersey is comprised in the belt of country about 18 miles wide and 60 miles long which is marked by the mountains of that name, and which extends from the New York boundary in a southwest direction to the Delaware. This belt of mountains consists of a succession of shorter parallel ridges having nearly the same general direction with the main belt, but a little nearer to a north and south course. Some of the ridges are anticlinal in structure and others are synclinal, and the whole region appears to have been broken across in a N.W. and S.E. direction by great fractures with faults which are vertical or approaching that direction, and the masses of rock between any two adjacent faults have almost uniformly their southwest ends elevated and their northeast ends depressed. The workings of some of the iron and of the zinc mines have developed this changed condition of the strata in a very interesting manner. The inclination which the strata have taken in consequence of this longitudinal tilting is everywhere noted by the miners and is called the *pitch* of the ore-beds. It is very little in some instances, while in others it is as high as 70° or more. The force which has caused this tilting has also caused the strata to move upon each other, so that slickensides are very common in the rocks and in some of the iron ores. The pitch has also long

been noticed upon the crests of the shorter mountain ridges, where they terminate abruptly at their southwest ends, and, on the contrary, descend gradually towards the northeast until they are lost in the valleys.

This disturbance of the Archæan strata, in the folding, fracturing and tilting of the strata, is evidently older than the adjacent Silurian rocks, as they do not show the folding or the pitch conformably or to the same extent as the older rocks do, and the ridges are much longer. In the great interval of time since this disturbance of the strata occurred there has been an immense amount of material worn off from the rough and broken rocks of the surface, and the hard and unfractured strata are left exposed at the surface. The anticlinals worn off have left the areas of Massive rocks uncovered, and, on the contrary, the synclinals, from the nature of their folding being much less broken, have been less worn down, so that the synclinal structure of some of the ridges is plainly to be seen. This is notably the case at the Zinc mines at Franklin Furnace, Sussex county, and at the Iron mines, Hurdtown, Morris county, where the *pitch* is plainly seen to be only the angle of descent of the synclinal fold.

The surface of the country is so covered with drift and other loose materials of earth and soil that it is difficult to trace out the areas of different classes of rocks. But so much has been done upon the surface, as well as in the working of the mines, that the hypothesis of the folds and fractures in the rocks may fairly be taken as most consistent with the facts yet demonstrated, and as useful for a plan to guide in further investigations and surveys of the whole ground.

The deposits of iron and zinc ores appear to have been originally in long narrow strips, nearly if not quite parallel to the axes of the present ridges, and the axes of the folds are also in the same direction with the ore strips. In the iron ore at Hurdtown the axis of folding is near one edge of the strip of ore. It shows very plainly at the southwest end, near the old Hamburg turnpike, the whole synclinal fold being in plain sight. And a cross fracture some 600 feet to the northeast has been followed by fault in which the ore beyond the fault was raised 180 feet. The mining has continued on the line of *pitch*, which is near 40° for more than 2,700 feet.

At the Zinc mines at Franklin Furnace the axis of folding is in the strip of zinc ore and apparently not very far from its edge. The end of the fold is plainly exposed at the southwest opening of the mines,

where the ore in that direction terminates. As the fold descends towards the northeast the two edges of the strip of ore outcrop on the surface in divergent lines. That on the northerly side extends on towards the northeast for 2,300 feet. That on the easterly side extends onward for 600 feet and then pitches beneath the surface at an angle of 29°, which is the same as the pitch of the synclinal axis. The openings have extended along the whole of both the outcrops, and some of them have extended down to a depth of 250 feet beneath the surface, and in the bottom of one part of the openings a cross-cut has been driven from one side to the other, following the bottom of the fold of ore. Careful and detailed measurements have been made of all parts of this ore body which have been opened, and their relative positions, for the purpose of constructing a model of the ore deposit and the rocks adjacent. This model is intended not only to show the structure of Mine Hill and its ores, but also to illustrate one of the prevailing and characteristic structural features of the whole Archæan region.

The plan for the survey of this region contemplates the studying out and locating the several areas of massive rocks, and those of the iron-bearing rocks, and as far as possible the location of the great folds and faults which have given the peculiar features to the whole mountain country, and in its economic relations will give assistance and direction to the working of the rich iron ore deposits which constitute the wealth of this Highland region.

Dr. Britton "spent the month of September, 1887, in a Geological Survey of the portion of Sussex county lying between Franklin Furnace on the north and Andover on the south, bounded on the east by the Wallkill and on the west by the Lehigh and Hudson River railroad. Special attention was given to the study of the Archæan rocks in continuation of former work on that system. The areas underlaid by the three groups of strata defined in last year's report as represented in the territory above described have been laid down on the Topographical Map of the State. The iron-bearing group is only sparingly developed in this region, most of it being occupied by the Gneissic and Schistose rocks of the upper group. The outcrops of white limestone were quite carefully explored and mapped."

Dr. Britton has discovered in the crystalline rocks which he examined last Summer a fossil plant, which he has named Archæophyton Newberryanum. These rocks have been considered to belong to

the Archæan series, and this discovery will call for a careful and thorough re-examination of this interesting group of rocks which lie along the northwestern base of the Highlands.

The *Raritan Clay-Beds*, which have been considered to be of the Cretaceous system, are likely to have more attention drawn to their place in the geological series, by the discovery of various fossils in clays of similar appearance and general character in Maryland, Virginia and other States farther south. These fossils are thought to more nearly approach those of the Jurassic system than those of the Cretaceous. None of them have as yet been found in our New Jersey clays.

There is an outlying deposit of clay and sand in Middlesex county, one or two miles north of Monmouth Junction station, on the Pennsylvania railroad. It is locally known as the Sand Hills. It is quite to the northwest of the main deposits of the Cretaceous system, and is partly cut off from them by a low ridge of trap rock, and is undoubtedly underlaid by the red sandstone and shales. The main and most notable portion of the surface is sandy and much like the surface of the country in which the clay-beds occur farther south. White clay is found exposed for a considerable distance along the western side of this district. It has been met in many wells which have been dug in it near its northern border, and it has been found along the straight turnpike near the eastern foot of the Sand Hills. Clay has also been found in a number of other places in the Hills by persons who are boring in search of clay for potters' use. Nothing has yet been found to prove that it is in any way different from the lower of the Raritan clay-beds, which it so closely resembles, but its singular isolation and its location so far to the northwest of the rest of the system may well awaken an interest as to its geological age. There have been but few openings made in it, but it must hereafter receive a much more thorough examination.

IV.
WATER-SUPPLY.

The demand for public supplies of pure water for household uses and for use in various industries is constantly increasing. Already there are 50 cities and towns provided with public water-works in the State, and 790,000 of our population are dependent upon these works for their supply of drinking-water. There is inquiry for more, and in Newark and Jersey City, comprising nearly half the above population, there is a pressing demand for improvement in the quality of water furnished. Large wells have yielded the supplies needed for some of our towns—the quality and quantity being satisfactory. In some other cases water of unsatisfactory quality has its impurities precipitated by chemicals and removed by filtration. By far the larger portion, however, is supplied from streams without any preparation, except the settling of impurities in reservoirs. In most waters of streams there is some organic matter, perhaps harmless in character, but subject to fermentation or changes when left to stand in reservoirs or pipes. The result is noticed in a slightly disagreeable taste and smell, which may last for some days or even weeks. Though the water is disagreeable, no ill effects follow from its use. This characteristic of brook and river waters has been well known to sea-going men, and is by them considered to be a process of purification. In the casks in which water is carried to sea, it always goes through this disagreeable stage, and is then much better liked than it was before.

The larger streams from which water is taken are liable to be polluted by drainage from sewers, and possibly by products of disease from the drains of houses where contagious sickness prevails. Such cases are not common, but the fatal consequences which follow when they do occur should lead those who provide water-supplies to guard against them by every means in their power.

The water which supplies Newark and Jersey City is taken directly

from the Passaic river at or near Belleville, where it is slightly contaminated with salt water brought in by the tide, and is polluted by the filth from the sewers of Newark, and by the drainage of all sorts from Paterson and Passaic. A number of surveys and reports upon the sources for a supply of pure and wholesome water for these cities have been made, and it is demonstrated that an abundant supply for both cities can be had in the mountainous districts about the headwaters of the Passaic. It is also shown that the supply can be delivered by gravity, and that the distance to bring it is only 20 miles, and that the quality of the water is unexceptionable and the expense of procuring it not burdensome. These advantages are greater than those possessed by New York, or Philadelphia, or Boston, or, in fact, by almost any other of our large cities.

The Topographic Maps 4 and 7, of the Passaic water-shed, with its area and elevations, contain the information which is sought by those inquiring into the particulars desired in planning for a water-supply for those cities, and a study of them will show the numerous and well-adapted locations which are available for the storage and supply of water.

A Relief Map of the State on a scale of 5 miles to one inch, has also been prepared by the Survey, which gives the drainage and sources of water-supply from streams over the whole State. An examination of this map with its streams of water, its valleys, hills and mountains, will show to any intelligent person the sources of supply, the elevation at which the water can be obtained, and data for determining the line to be followed in conducting the water, and its distance to the place where it is to be used.

ARTESIAN WELLS.

A number of wells have been bored in the State during the last year. Those along the Atlantic border south of the Raritan have in the main been successful. The geological structure of this portion of country has been fully described in former reports, and the results obtained by boring continue to verify the correctness of the description as then given. The water-bearing strata have been proved to a greater extent by some of the wells. A good flowing well has been obtained at 240 feet at Harvey Cedars, on Long Beach, and one on

the mainland at 120 feet at Barnegat. These are both supplied from the water-bearing stratum in the clay deposits over the marl.

A boring at Atlantic City which should have tapped this stratum at between 500 and 600 feet was unsuccessful in getting water, and has been sunk still lower. It is now down 1,121 feet and a water-bearing stratum has not yet been opened. It is nearly down to the Upper Marl-Bed, underneath which good water has been found at Winslow and at Berkeley Arms. It may be that the stratum in the clay where water is found at the other wells is too close for a free flow of the water—such has been found to be the case in several instances at Asbury Park, and there, by changing the location for a few hundred feet and sinking the well, a good flow of water has been obtained. It would be useful to have other trials at Atlantic City, locating the wells at some distance, say 500 feet or more from the last one. The artesian well-water is free from all organic impurities, and pure enough to meet the wants of the most fastidious. A three or four-inch tube is large enough, and such a tube can be sunk to the depth needed for from $2 to $3 a foot.

A good well at Bay Head is sunk 710 feet to the stratum which supplies Asbury Park, Ocean Beach and other places on the shore.

It requires skill and experience to bore wells successfully in the soft earthy materials of which the formations on the shore are entirely made up. Some of those who have been long in the business have acquired remarkable facility in putting down good wells at the smallest cost, and, on the contrary, those inexperienced in boring wells in stratified sand and clay have made serious and expensive mistakes. Last year a person skilled and experienced in boring wells in rock, undertook to put down a well in these South Jersey deposits. He was notified that the water would be found at 300 feet, and on boring to that depth with his usual methods he could get no water. He continued the boring further to the depth of 500 feet, without getting water, and then left the work. One experienced in the business then sunk a well a yard or two from the former and obtained an abundant supply at 297 feet. There have been a number of other failures which were plainly due to the lack of skill in those doing the work. On the Delaware slope a number of wells have been bored, some of which yield a moderate supply of water, but others of them are failures. Those near the river are in strata which are geologically below those from which the water is obtained on the Atlantic side, and those

which are higher up are on the outcropping edges of strata from which water is likely to escape without rising in a well.

Borings in the red sandstone are uncertain. A well at New Brunswick, bored for Messrs. Johnson & Johnson in the red rock, is 480 feet deep and yields a moderate supply of very hard water. One bored in the red sandstone in the marsh west of Hoboken is down 250 feet, but yields only brackish water.

A well has been sunk at the clay-banks of Sayre & Fisher, at Sayreville, on the right bank of the Raritan, to get a supply of pure water for steam boilers. It is 8 inches in diameter. The first 70 feet were in clay, and then Gneiss rock was met. The well is now 893 feet in the Gneiss and no water has been met, and it is not likely that any will be found, though the boring is still continued.

V.
DRAINAGE.

The act to provide for the drainage of lands which was passed in 1871 required that at the request of owners of any tract of land subject to overflow from freshets, or which is usually in a low, boggy or wet condition, the Board of Managers of the Geological Survey are authorized to examine such tract, and if they deem it for the interest of the public and of the land-owners, they are authorized from time to time to make surveys of any such tract, and to decide upon and adopt a system of drainage, &c., and to call in the assistance of the State Geologist and others. Under this act there have been surveys made, and plans of drainage adopted for lands on the Passaic and its branches between Little Falls and Chatham, on the same stream between Chatham and Millington, and on the Pequest, in Warren county, between Vienna and Long Bridge. The latter of these has been successfully carried out, and the Great Meadows, a tract of 5,000 acres or more, of almost worthless land, has been thoroughly drained and is now the richest and most productive land in Warren county, and the people on the adjoining lands, formerly afflicted with the worst forms of malarial disorders, are now as healthy as any in the State. The plan for drainage on the Passaic above Chatham has not been carried out. That for the tract on the Passaic between Little Falls and Chatham, is in charge of Commissioners to be carried out. The land affected may amount to from 11,000 to 15,000 acres. From its location in a very flat and nearly level valley, which is bounded on every side by mountainous or hilly ground, the drainage from the high grounds finds its way to this flat valley very rapidly, where it soon accumulates and overflows this large tract. There were natural obstructions to the flow of the stream at Two Bridges and at Little Falls, and a dam at the latter place higher than either prevents or renders useless their removal. The overflow drains off with extreme slowness, and the lands themselves cannot be thoroughly drained as

long as these obstructions remain. The only use made of these wet grounds is to gather from them crops of coarse wild grass, and in wet seasons even these are destroyed. This was the case in the summer of 1887. But the greater damage still is to public health,—malarial diseases are far more prevalent than in the well-drained counties, and the depressing influence of an atmosphere charged with such vapors is felt by all. The delay in carrying through the work of removing the obstructions to the free flow of the stream, and so to the passage of all the water in its channel, is caused by the difference of views as to the sum to be paid for damages to water-power. The Beattie Manufacturing Company, whose interests will be affected by the removal of the dam and obstructions, set a higher value upon their ownership in the dam and stream than the Commissioners have awarded, and the question of valuation has to be tried in the courts.

The case is one of great public interest for the sanitary and property advantages to be gained, and also because if carried through as successfully as similar improvements have always been in other cases, it will encourage efforts to reclaim other large tracts in the State which are now almost worthless in themselves, and damaging to the districts in which they lie. The tracts offering most encouragement to drainage and improvement will be given in more detail in the report on the Physical Geography of the State.

VI.
MISCELLANEOUS PAPERS.

MUSEUM OF THE GEOLOGICAL SURVEY.

The burning of the State House in 1885 destroyed many of the specimens which were collected and on exhibition there. Fortunately a good representation of them was away on exhibition at the New Orleans Exposition, and was saved. These are now stored in the State Arsenal at Trenton. In the new State House now being erected, a convenient, spacious and well-lighted room has been set apart for the museum. The building will probably be ready for use in 1888. And it is the plan of this Survey to make and arrange as complete a collection as possible of its rocks, minerals, ores, limestones, building stones, slates, soils, marls, clays, sands, &c.; also collections of its plants and animals. And it is intended also to put on exhibition as large a collection as possible of the fossils found in the State, and of the implements and other relics of the men who formerly had our State for their home.

Jerseymen and other friends who desire to have these objects of interest brought together and preserved for public inspection, have already tendered their aid in making collections for the museum, and the contributions of others who may have objects in these lines, are solicited. Notice of contributions may be sent to the State Geologist, at New Brunswick. A record of the gifts and deposits will be made and published.

VII.
PUBLICATIONS OF THE SURVEY.

THE ANNUAL REPORTS OF THE STATE GEOLOGIST are printed by order of the Legislature, and as part of the legislative documents. They are distributed largely by the members of the two houses. Extra copies are supplied to the Managers of the Geological Survey and the State Geologist, who distribute them to libraries, public institutions, and, as far as possible, to any who may be interested in the subjects of which the reports treat. Most of the reports of former years have been distributed, and the editions are exhausted.

THE REPORT ON FIRE AND POTTERS' CLAYS OF NEW JERSEY has been widely distributed. Of the copies which were left, most of them were lost in the burning of the State House, and but few copies are remaining.

THE PRELIMINARY CATALOGUE OF THE PLANTS of the State has been generally distributed among botanists, so as to get in return reports of the localities of plants, and to thus have the assistance of botanists in making a *complete* list of all our plants. The revision is going on; several new plants have been discovered during the last year, and many new localities of well-known plants have also been found. The co-operation of botanists in getting new species is earnestly solicited. It is proposed to print the revised catalogue at the end of 1888.

A TOPOGRAPHICAL MAP OF A PART OF NORTHERN NEW JERSEY, on a scale of 1 mile to an inch, is printed, and has been distributed to some extent. In addition to the delineation of boundaries, streams, roads and geographical matter, it has on it contour lines of level, so that the elevations of the surface above mean tide are accurately marked on all parts of it. This map has been very generally approved, and is in demand for laying out drains, ditches,

water-works, roads and railroads, and for selection of building-sites, and as a study for drives, bicycle excursions, &c.

THE ATLAS OF NEW JERSEY is now in the hands of the engraver and printer and the sheets will be all done by the month of March. These sheets are each 27 by 37 inches, including margin, and are intended to fold once across, making the leaves of the atlas 18½ by 27 inches. The completed work will be made up of 17 of these maps, on a scale of 1 mile to the inch, and 2 maps of the whole State, on a scale of 5 miles to the inch. The location and number of each map are given on the reference map, facing page 11 of this report, and are printed on the paper cover of the atlas.

The following is a list of the titles of the sheets, with their numbers:

No. 0. New Jersey State Map. Scale, 5 miles to an inch. Geographic.

No. 1. Kittatinny Valley and Mountain, from Hope to the State line.

No. 2. Southwestern Highlands, with the southwest part of Kittatinny valley.

No. 3. Central Highlands, including all of Morris county west of Boonton, and Sussex south and east of Newton.

No. 4. Northeastern Highlands, including the country lying between Deckertown, Dover, Paterson and Suffern.

No. 5. Vicinity of Flemington, from Somerville and Princeton, westward to the Delaware.

No. 6. The Valley of the Passaic, with the country eastward to Newark and southward to the Raritan river.

No. 7. The Counties of Bergen, Hudson and Essex, with parts of Passaic and Union.

No. 8. Vicinity of Trenton, from New Brunswick to Bordentown.

No. 9. Monmouth Shore, with the interior from Metuchen to Lakewood.

No. 10. Vicinity of Salem, from Swedesboro and Bridgeton, westward to the Delaware.

No. 11. Vicinity of Camden, to Burlington, Winslow, Elmer and Swedesboro.

No. 12. Vicinity of Mount Holly, from Bordentown southward to Winslow and Woodmansie.

No. 13. Vicinity of Barnegat Bay, with the greater part of Ocean county.

No. 14. Vicinity of Bridgeton, from Allowaystown and Vineland, southward to the Delaware bay shore.

No. 15. Southern Interior, the country lying between Atco, Millville and Egg Harbor City.

No. 16. Egg Harbor and Vicinity, including the Atlantic shore from Barnegat to Great Egg Harbor.

No. 17. Cape May, with the country westward to Maurice river.

New Jersey Relief Map. Scale, 5 miles to the inch. Hypsometric.

GEOLOGICAL MAP OF NEW JERSEY.—Scale, 6 miles to an inch. Out of print. The new State Map, No. 0, will be prepared to take its place soon.

DISTRIBUTION.—The Board of Managers of the Geological Survey is made by the terms of the law "a committee of publication, with authority to print and publish the annual and final reports of the State Geologist" ——— "as will best conduce to the interests of the citizens of the State." The Geology of New Jersey, printed in 1868, was published by the Board. And the engraving and printing of the Topographic and Geologic Maps have also been published by their authority. But the printing of the annual reports and their distribution, and to some extent the distribution of the maps and special reports, have been by the Legislature and its members. This has tended to a very general distribution of the publications of the Survey among the people of the State, who have approved this method, and in many cases have turned the practical suggestions of the reports to useful purposes.

The distribution of so many and such expensive reports and maps among the people, seems almost unwarranted, but the continued and rapid growth of the State in all its material interests, may be considered as proving that this general publication of its natural resources and advantages, is an advertisement for it, and that the information disseminated in this way brings a quick return. If a price were put upon the publications they would not be so widely circulated, and their benefits would be attained much more slowly. A complete register is kept of all maps and reports which are sent out from the office of the Survey, and in the case of the maps it is intended to keep a record of all that are sent out, and of the persons to whom sent. Applications

for them made in good faith, and by citizens who wish them for their own use, are responded to as far as possible.

Copies are sent to all known public libraries in the State, and to those of New York, Brooklyn and Philadelphia, and to all the State libraries; also to State officers, to judges of the Supreme Court, to many surveyors and engineers, to persons engaged in public works, to many geologists and naturalists, and to many others who have been accredited by members of the Board or by public officers.

A list of the members of the Board of Managers of the Geological Survey, with their address, is given at the beginning of this report, and persons desiring to secure copies of any of the publications will please make application through a member representing the congressional district in which they reside. The results of the survey are intended for the benefit of the citizens of the State, and the Board of Managers have charge of and direct the distribution of its collections, reports, &c., and application made for publications to them, or through them to the State Geologist, will be received and given due attention.

VIII.
EXPENSES.

The expenses of the Survey have been kept strictly within the annual appropriation of $8,000. To do this has required much care and the contraction of some branches of the work. The completion of the Topographic Survey this year has required that an unexpectedly large proportion of the funds should be used in that work; but nearly all that is now done, and in future the whole amount of the appropriation can be used for the purpose of completing the geological work.

The expenses of Topographical Surveys paid by the United States Geological Survey were—

From July 16th, 1884, to June 30th, 1885	$9,213 03
From July 1st, 1885, to June 30th, 1886	11,999 95
From July 1st, 1886, to June 30th, 1887	9,996 75
From July 1st, 1887, to December 31st, 1887	3,648 98
Total	$34,858 71

The expense of the Geodetic Survey is paid by the United States Coast and Geodetic Survey. The expenses of the Magnetic Surveys, and of setting and verifying bench-marks, have been paid from the New Jersey appropriation.

IX.
ASSISTANTS EMPLOYED.

Dr. NAT. L. BRITTON, of Columbia College School of Mines, has been employed for a few weeks in extending the survey of the Archæan rocks of the Highlands. He still has the revision of the New Jersey flora in hand, and it will be kept open for additions another season.

Prof. ALFRED A. TITSWORTH, of Rutgers College, has been engaged in making a careful survey of the zinc mines at Franklin Furnace, for the purpose of making maps of the mines, and a model to show the workings and their teachings.

Mr. FRED. J. H. MERRILL, PH.B., has spent a short time in the survey of the glacial and terrace deposits of the Delaware valley above the Water Gap.

Prof. R. P. WHITFIELD is still continuing his work in describing the invertebrate fossils of the Cretaceous and Tertiary formations.

Dr. J. S. NEWBERRY has the fossil flora and fishes of the Trias, and the flora of the Tertiary, still in hand, but it is about ready for publication.

Mr. C. CLARKSON VERMEULE, Topographer in Charge, has prosecuted the Topographical Survey throughout the year, and has completed the field work and mapping. A Magnetic Survey has also been made. In his work he has been aided by the following assistants, most of whom have resigned to accept other positions as the work has approached completion:

Mr. F. W. BENNETT, Assistant Topographer, was engaged in topographical work until October 13th, and in making magnetic observations until November 26th, the date of his resignation.

Mr. P. H. BEVIER, Assistant Topographer, was occupied with topographical work and triangulation until September 30th, when he tendered his resignation.

Mr. W. H. LUSTER, JR., Assistant Topographer, resigned September 15th, having been engaged in sketching topography until that time.

Mr. P. D. STAATS, Assistant Topographer, was steadily occupied with field work until October 1st, and in the office from that time until the date of his resignation, December 3d.

Mr. ASHER ATKINSON, Assistant Topographer, has been steadily engaged in field and office throughout the year. He assisted with the Magnetic Survey during October and November.

Mr. CYRUS F. SPROUL, Draughtsman, assisted in the office until the 11th of June, when he resigned.

Mr. FRANK VAN BRAKLE, Draughtsman, has been employed throughout the year mapping, measuring areas and at other office work of a miscellaneous character.

Mr. N. B. K. HOFFMAN resigned June 30th, and Mr. WM. F. MARVIN, September 5th, both having been mainly occupied with surveying roads.

All of the above assistants were employed in the office until the resumption of field work, April 1st.

Messrs. J. B. REYNOLDS, C. M. DU BOIS, L. M. RICE, WM. C. OGDEN, H. J. MARCH and I. L. WINCKLER were employed as field aids during a portion of the year.

X.

STATISTICS OF IRON AND ZINC ORES.

IRON ORE.

The output of the iron mines of the State for the year 1887, as shown by the shipments of iron ore from stations in the State and the amounts used at furnaces which do not come in the tonnage of the railroad lines, aggregated 547,889 tons—an increase of 47,388 tons as compared with the production of 1886. For the convenience of reference the statistics of iron ore mined in the State for the years 1870–1887, inclusive, are here inserted in a tabular form. Estimates and U. S. census figures at intervals back to 1790 are also given at the head of the column:

1790.....	10,000 tons.....	Morse's estimate.	
1830.....	20,000 tons	Gordon's Gazetteer.	
1855.....	100,000 tons.....	Dr. Kitchell's Estimate.	
1860.....	164,900 tons.....	U. S. census.	
1864.....	226,000 tons.....	Annual Report State Geologist.	
1867.....	275,067 tons.....	"	"
1870.....	362,636 tons.....	U. S. census.	
1871.....	450,000 tons.....	Annual Report State Geologist.	
1872	600,000 tons.....	"	"
1873.....	665,000 tons.....	"	"
1874.....	525,000 tons.....	"	"
1875.....	390,000 tons.....	"	"
1876.....	285,000 tons*.....		
1877.....	315,000 tons*.....		
1878.....	409,674 tons.....	"	"
1879.....	488,028 tons.....	"	"
1880.....	745,000 tons.....	"	"
1881.....	737,052 tons	"	"
1882.....	932,762 tons	"	"
1883.....	521,416 tons.....	"	"
1884..	393,710 tons.....	"	"
1885	330,000 tons.....	"	"
1886.....	500,501 tons.....	"	"
1887.....	547,889 tons.....	"	"

*From statistics collected later.

This tabular statement shows that from 1870 to 1874 there was a gradual and steady increase in the annual production. The financial depression in the latter part of 1873 marked a turn in the rate of production, and the lowest output for the decade was reached in 1876. The product for 1877 was slightly in excess of that of 1876, and from that year onward there was a gradual rise to the boom of 1879, which showed itself in the large increase in 1880. The maximum was attained in 1882. The decline since has been marked, until 1885, since which there has been an increase.

ZINC ORE.

The product of the zinc mines for the year 1887, as shown by the shipments over the transporting lines, was 50,220 tons.

The following tabular statement shows the production of the zinc mines of New Jersey for a number of years:

	Estimated tons.			
1868	25,000	Annual Report State Geologist.		
1869				
1870				
1871	22,000	"	"	"
1872				
1873	17,500	"	"	"
1874	13,500	"	"	"
1875				
1876				
1877				
1878	14,467	"	"	"
1879	21,937	"	"	"
1880	28,311	"	"	"
1881	49,178	"	"	"
1882	40,138	"	"	"
1883	56,085	"	"	"
1884	40,094	"	"	"
1885	38,526	"	"	"
1886	43,877	"	"	"
1887	50,220	"	"	"

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